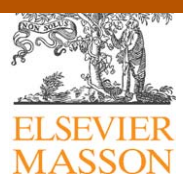
Orthopaedics & Traumatology: Surgery & Research (2011) 97, 246—251



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ORIGINAL ARTICLE

Acromio humeral distance less than six millimeter: Its meaning in full-thickness rotator cuff tear

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Accepted: 18 January 2011

KEYWORDS
Acromiohumeral distance;
Full-thickness rotator cuff tear;
Muscular fatty degeneration;
Cuff tear suture repair

Summary The present study sought to identify full-thickness rotator cuff tears liable to induce an acromiohumeral distance (AHD) of less than 6 mm. The hypothesis was that, less than 6 mm AHD is found exclusively in association with total full-thickness infraspinatus tear.
Materials: A continuous single-center series recruited 109 shoulders, free of glenohumeral osteoarthritis, presenting with full-thickness tear requiring surgery. Preoperative acromiohumeral distance, rupture location and extension on the various tendons and muscular fatty degeneration (FD) were known.
Methods: Full-thickness tears were categorized by location and extension on the various tendons. For each group, the number of shoulders showing AHD < 6 mm was determined.
Results: Total full-thickness infraspinatus tears were almost the only tendon lesions able to induce AHD < 6 mm, but this only when the infraspinatus muscle showed FD equal to or greater than 2.25: i.e., when the tear was longstanding.
Discussion: Unlike previous reports, the present study took account of the total or partial nature of infraspinatus and subscapularis tendon tear. The findings may suggest that AHD < 6 mm is induced by posterior migration of the humeral head secondary to longstanding total infraspinatus tear, reducing AHD projection height on X-ray.
Conclusion: AHD < 6 mm is a sign of rotator-cuff rupture almost systematically involving longstanding total infraspinatus tear, not always amenable to suture repair due to advanced fatty degeneration. AHD equal to or greater than 6 mm is of no diagnostic relevance and in no way indicates whether there is subscapularis tear and, if so, whether suture repair is feasible.
Level of evidence: Level IV (retrospective study).

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doi:10.1016/j.otsr.2011.01.010

Introduction

Acromiohumeral distance (AHD) measures the space between the humeral head and the acromion. AHD measured on X-ray images with the patient in standing or seated posture is cited in all reports of rotator cuff tear and its treatment. Mean AHD in absence of rotator cuff tear is 10.5 mm [1], with a range of 6 to 14 mm according to Cotton and Rideout [2] or 7 to 13 mm according to Weiner and Macnab [3]. AHD is of diagnostic interest due to its high specificity but low sensitivity. AHD equal to or less than 7 mm indicates rotator cuff tear with 75% specificity [4] and, according to Nové-Josserand et al. [5,6], indicates full-thickness infraspinatus tear with or without other associated cuff tendon lesions. It is also of prognostic interest. AHD equal to or less than 7 mm (statistically correlated with severe infraspinatus muscle fatty degeneration (FD) [5,6]) is suggestive of recurrent tear following suture [5—8]. Classically, reduced AHD is explained by loss of infraspinatus lowering function, so that the humeral head can rise because the torn supraspinatus tendon is no longer in the subacromial space [5,6,9,10].

The present study sought to identify full-thickness tendon tears liable to induce less than 6 mm AHD. The working hypothesis was that only total infraspinatus tear can be associated to so small an AHD.

Material

The study material comprised 109 of the 113 full-thickness cuff tears repaired in our center between 1994 and 1997. Fifty-seven of the subjects were male, and 86 of the shoulders were left. All were free of glenohumeral osteoarthritis. On the Hamada classification [11], 26 shoulders were grade II (AHD $\leq$ 6 mm), and all the others grade I. On the Samilson and Prieto classification [12], 71 shoulders were free of glenohumeral osteophytes, 37 had grade-1 osteophytosis, and only 1 was grade 2. Mean age at surgery was 57.9 years (SD $\pm$ 7.5 yrs; range, 28—72 yrs).

In these 109 shoulders, radiologic AHD, full-thickness tear location on the tendons and pre-operative supraspinatus, infraspinatus and subscapularis FD were known. AHD, measuring the space between the tangent to the densified inferior edge of the acromion and the parallel tangent to the superior part of the humeral head, was assessed (in mm) from non-digitized X-ray views. The patient was seated or standing, with the upper limb loose, elbow to the body, in neutral rotation. The X-ray bulb was at 1 m from the film. The rays (under visual control) were aligned to the inferior side of the acromion, visualizing the subacromial space and glenohumeral joint space. The tendon location of full-thickness tears (ignoring non-full-thickness tears) was noted during surgery, which used a deltopectoral approach for isolated subscapularis tear and a supraspinatus-transacromial-transdeltoid approach for other tears. The latter approach allowed easy location [13] of the various torn tendons, determining the extent of full-thickness tear in each. FD was assessed on horizontal CT soft-tissue windows (one slice for the supraspinatus and two for the infraspinatus and subscapularis [14]) on the Goutallier and Bernageau classification [15]. The series was continuous, single-center and retrospective.

Method

Full-thickness rotator cuff tears were divided into five groups according to tendon location: isolated supraspinatus or subscapularis, supra-plus-infra-spinatus, supraspinatus-plus-subscapularis, or all three tendons. Subgroups were distinguished according to extension in each tendon: ''total'' when involving between two thirds and the whole of the tendon, and ''partial'' when involving less than two thirds (i.e., in the case of infraspinatus and subscapularis tears, less than the two superior thirds).

Data were analyzed using StatView, version 4.55 software (Abacus Concepts Inc., Berkeley, CA). Statistical analysis used the Student t test, simple regression and bivariate linear regression. The significance threshold was set at $p < 0.05$.

Results

Eighteen AHDs were less than 6 mm. Such small AHD values were found only in association with full-thickness infraspinatus tear: in five of the 16 total supra- plus infraspinatus tears, 10 of the 22 3-tendon tears with total infraspinatus tear, and three of the 27 3-tendon tears with ''partial'' superior infraspinatus tear (Table 1). Table 1 also shows mean values, standard deviations and ranges for AHD in the various groups and subgroups.

For the three location groups, the only significant differences in AHD were between 3-tendon and either supraspinatus-plus-subscapularis ($p = 0.0055$) or isolated subscapularis tear ($p = 0.0065$), and between supra-plus-infra-spinatus and either supraspinatus-plus-subscapularis ($p = 0.0246$) or isolated subscapularis tear ($p = 0.0111$). For the subgroups, the only significant differences in AHD were between total supra-plus-infra-spinatus and either supraspinatus-plus-total-subscapularis ($p = 0.0122$) or isolated total subscapularis tear ($p = 0.0003$). There was also a significant differences in AHD between 3-tendon tears including total infraspinatus-plus-subscapularis and those including partial infraspinatus with total subscapularis tear ($p = 0.0363$).

AHD < 6 mm ($n = 18$) and full-thickness infraspinatus tear extension

Fifteen AHDs of less than 6 mm were found in subgroups including total infraspinatus tear (5 of the 16 total supra-plus-infra-spinatus tears and 10 of the 22 3-tendon tears including total infraspinatus tear). The other three less than 6mm-AHDs (all 5 mm) were in the subgroup of 3-tendon tears with only superior infraspinatus involvement (the associated subscapularis tears being total in one case and superior in two).

AHD < 6 mm ($n = 18$) and subscapularis tear

Thirteen of the 71 subscapularis tears (34 of which were total) were associated with AHD < 6 mm. Rotator cuff tear

Table 1 Mean acromiohumeral distance (AHD), standard deviation (±) and range per cuff-tear group and subgroup, and number of AHDs < 6 mm per subgroup.

Group								
Full-thickness tear $n = 109$	Suprasp + infrasp $n = 29$		Isolated suprasp $n = 9$	Suprasp + subscap $n = 13$		Isolated subscap n = 9	Suprasp + infrasp + subscap $n = 49$	
AHD (mm) $n = 109$	8.1 ± 2.8 (1—12)		7.9 ± 1.5 (6—10)	9.5 ± 1.4 (7—12)		9.8 ± 1.5 (8—12)	7.5 ± 2.4 (3—12)	
Subgroup								
	Total infrasp tear $n = 16$	Sup. infrasp tear $n = 13$	All total $n = 9$	Total subsc tear $n = 6$	Sup. subsc tear $n = 7$	All total $n = 9$	Total infrasp tear $n = 22$	Sup. infrasp tear $n = 27$
AHD (mm)	6.6 ± 2.6 (1—10)	10 ± 1.8 (6—12)	7.9 ± 1.5 (6—10)	9.5 ± 1.6 (7—11)	9.6 ± 1.3 (8—12)	9.8 ± 1.5 (8—12)	6.7 ± 2.6 (3—12)	8.2 ± 2.1 (5—12)
AHD < 6 mm								
Number	5	0	0	0	0	0	10	3
Mean (mm)	3.4						4.3	5
Range (mm)	1—5						3—5	5—5

Suprasp: supraspinatus; Infrasp: infraspinatus; Subsc: subscapularis; Sup: superior; T: tendon.
Significant intergroup differences in AHD were found between:

- 3-T and suprasp+ subsc tear: $p = 0.0055$;
- 3-T and isolated subsc tear: $p = 0.0065$;
- Supra + infrasp and suprasp + subsc tear: $p = 0.0246$;
- Supra + infrasp and isolated subsc tear: $p = 0.0111$.

Significant inter-subgroup differences in AHD were found between:

- Total supra + infrasp and suprasp + total subsc tear: $p = 0.0122$;
- Total supra + infrasp and isolated total subsc tear: $p = 0.0003$;
- 3-T (infrasp and total subsc) et 3-T (sup. infrasp and total subsc) tear: $p = 0.0363$.

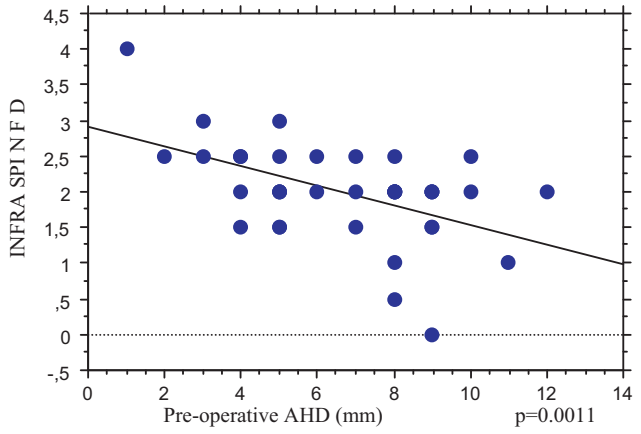

Figure 1 Linear regression between infraspinatus fatty degeneration (FD) and acromiohumeral distance (AHD) for the 38 shoulders with total full-thickness infraspinatus tear.

systematically involved all three tendons. Subscapularis tear was associated with total infraspinatus tear in ten cases (the subscapularis tear being total in four cases and superior in six).

It thus seemed that total full-thickness infraspinatus tear was a necessary condition for less than 6 mm AHD in 2-tendon tears and nearly necessary in 3-tendon tears.

Not all total full-thickness infraspinatus tears ($n = 38$), however, were associated with less than 6 mm AHD. There was a strong correlation ($p = 0.0011$) between AHD and FD in total infraspinatus tear: linear regression showed that, in total infraspinatus tear, the smaller the AHD the greater the FD and vice versa (Fig. 1). AHD < 6 mm was strictly associated with mean infraspinatus FD $\geq$ 2.25. It is to be borne in mind that FD levels in muscles with torn tendons correspond to the age of the tear [15,16] and, in the case of total tear, probably to the degree of torn tendon retraction. In contrast, shoulders with total full-thickness subscapularis tear without associated total infraspinatus tear ($n = 23$) (Fig. 2) showed no correlation between AHD and subscapularis FD

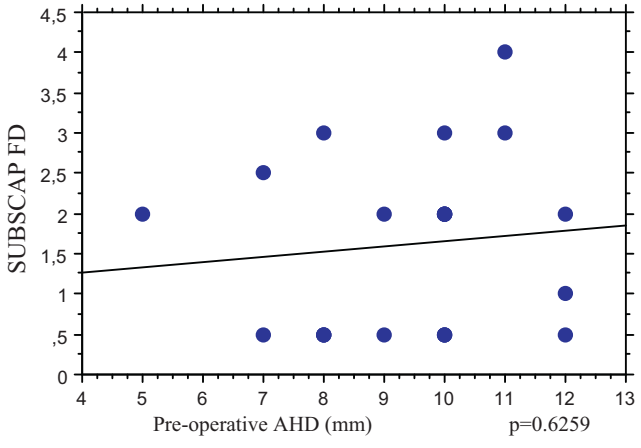

Figure 2 Linear regression between subscapularis fatty degeneration (FD) and acromiohumeral distance (AHD) for the 23 shoulders with total full-thickness subscapularis tear without total full-thickness infraspinatus tear.

($p = 0.6259$). From the scatter on the regression graph, it can be seen that AHD $\geq$ 6 mm was frequently found in association with subscapularis FD $\geq$ 2.

Discussion

In a series of 109 full-thickness rotator cuff tears, the present study focused not simply on preoperative AHD values but also on the number of shoulders showing AHD less than 6 mm, according to tear location (isolated supraspinatus or subscapularis, supra-plus-infraspinatus, supraspinatus-plus-subscapularis, or 3-tendon) and to total or merely superior infraspinatus or subscapularis full-thickness tear. Fifteen of the 18 less than 6 mm AHDs were in cuffs with total infraspinatus tear. AHD in rotator cuff tear involving total full-thickness infraspinatus tear correlated negatively with infraspinatus FD level; linear regression correlated less than 6 mm AHD with mean infraspinatus FD $\geq$ 2.25. In contrast, in total full-thickness subscapularis tear non-associated with total infraspinatus tear, AHD was almost never less than 6 mm and showed no correlation with subscapularis FD level. AHD $\geq$ 6 mm was frequently observed in association with subscapularis FD $\geq$ 2.

AHD measured from standing or seated X-ray views shows satisfactory reproductibility [17].

The present threshold of less than 6 mm corresponds to the lowest level reported in the literature for shoulders free of rotator cuff tear.

Nové-Josserand et al. [5,6] reported percentage low AHD in tear groups defined as in the present study and, as in the present study, found low AHD mainly in case of tear involving all 3 tendons or supra-plus-infra-spinatus: i.e., in case of infraspinatus involvement. They did not, however, notice the specific implication of total infraspinatus tear in low AHD. They did not distinguish between full-thickness and partial thickness or total full-thickness and merely superior infraspinatus tears. Moreover, they studied less than 7 mm and not less than 6 mm AHD; if a threshold of less than 7 mm had been used in the present series, five superior (and only two total) infraspinatus tears would have been additionally associated with ''low AHD'', obscuring the impact of total infraspinatus tear. Nové-Josserand et al. reported that, for their series taken as a whole, AHD decreased with increasing infraspinatus FD (a correlation not observed with respect to subscapularis FD). The present findings indicate two supplementary notions: in total infraspinatus tear, the higher the infraspinatus FD, the lower the AHD; and, in total full-thickness subscapularis tear without associated total infraspinatus tear, elevated FD is not incompatible with elevated AHD.

In the literature [5,6,8], low (< 7 mm) AHD indicates rotator cuff tear non-amenable to suture repair. In our opinion, AHD < 6 mm indicates total rupture, non-amenable to suture repair without tensioning of the infraspinatus due to an FD level likely to be greater or equal to 2.25 (Fig. 1), a level associated with failure of suture without infraspinatus tensioning [18]. On the other hand, in cases involving total subscapularis tear, large AHD does not rule out suture repair, since AHD > 6 mm is compatible with subscapularis FD $\geq$ 2 (Fig. 2), a level associated with failure of suture without subscapularis tensioning [18].

Reduced AHD is classically associated with superior migration of the humeral head induced by tearing of the infraspinatus, the main muscle involved in lowering the humeral head, made possible by the disappearance of the torn supraspinatus tendon from the superior subacromial space [5,6,9,10]. This account does not seem logical to us when the shoulder shows no osteoarthritis (i.e., when the shoulder joint is flexible). Total tearing of the subscapularis, also strongly involved in lowering the humeral head [10,19], whether isolated or with associated supraspinatus tear, does not induce reduced AHD (Table 1). It is rather the posterior migration of the humeral head, allowed by total infraspinatus tear, which reduces AHD by affecting the radiological projection of the subacromial space (Fig. 3). This posterior migration is induced by latissimus dorsi tonus pulling the superior humerus backward. The degree of posterior migration (and thus of AHD reduction) depends on the degree of retraction of the infraspinatus (and thus of the age of the tear), which may or may not withdraw from the posterior subacromial space. Posterior migration of the humeral head could account for the low AHD values found on X-ray of shoulders with rotator cuff tear in dorsal decubitus as compared to those taken in seated or standing posture [20]: this difference be as much as 2 mm in case of supra-plus-infra-spinatus tear. The authors, however, account for these differences in terms of removal of upper-limb weight, facilitating the rise of the humeral head. Posterior migration of the humeral head, on the other hand, was suggested by Werner et al. [17] to account for the fact that AHD measured on CT and MRI (i.e., in dorsal decubitus) was less (by 0.6 mm for rotator cuff tear) than on classical X-ray. But screening for posterior migration of the humeral head on CT or MRI appears unreliable: the humeral head may or may not be pushed forward, depending on whether or not it is being supported by the CT-scanner table (which, unlike X-ray tables, is mediolaterally concave) (Fig. 4) or MRI shoulder coil. Thus, no radiologic examination can currently confirm whether reduced AHD on standing X-ray is induced by posterior migration of the humeral head. The EOS system [21], which provides 3D reconstruction from images

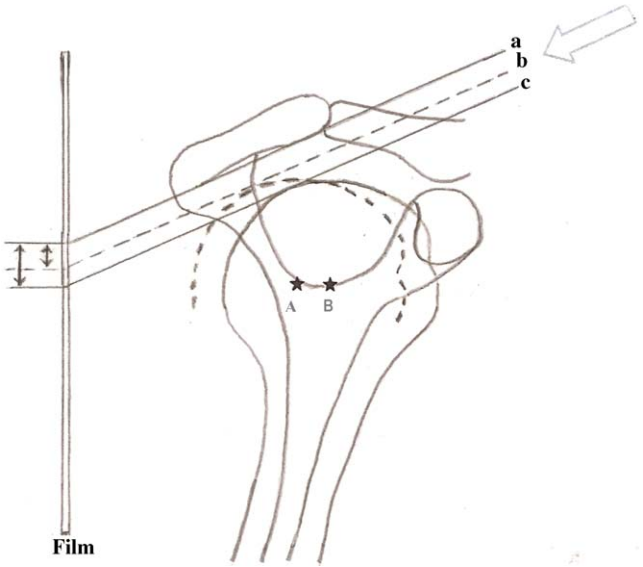

Figure 3 Variation in acromiohumeral distance on anteroposterior X-ray view according to anteroposterior humeral head position. a: tangent to the inferior face of the acromion; b: tangent (parallel to line ''a'') to the humeral head apex with posterior migration(A); c: tangent (parallel to line ''a'') to the centered humeral head (B). The acromiohumeral distance is lower when the humeral head is posteriorly migrated without superior migration.

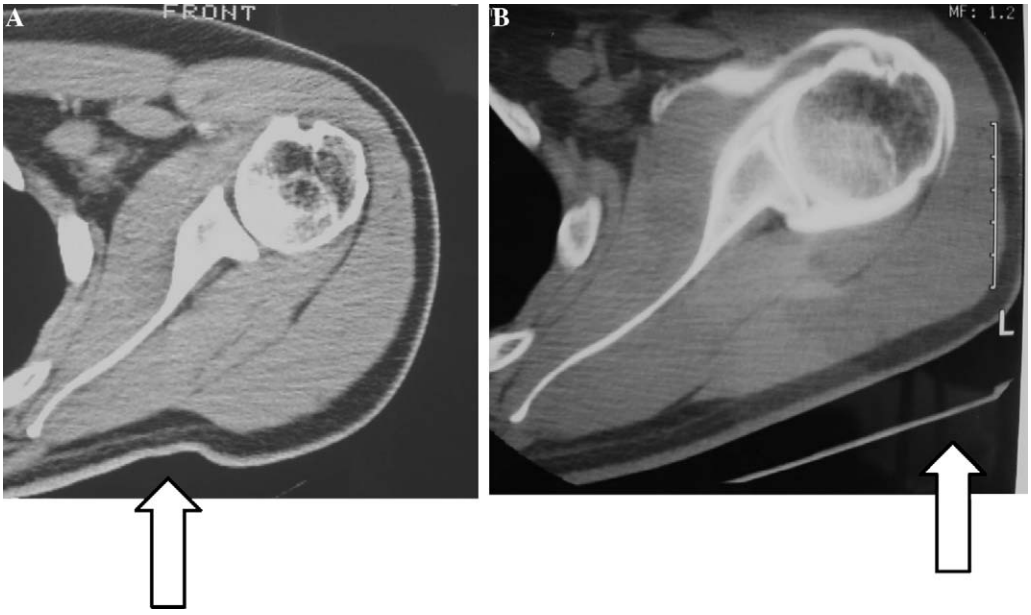

Figure 4 Variability of the posterior compression point on the shoulder during CT scan. A: the compression point is medial to the humeral head (arrow), which may migrate posteriorly. B: the compression point is lateral to the humeral head (arrow), which cannot migrate posteriorly.

obtained in seated or standing posture (i.e., in the same postures as allow X-ray assessment of AHD), may perhaps show correlations between AHD < 6 mm and superior or posterior migration of the humeral head.

Conclusion

The study confirmed its working hypothesis: cuff tears involving total infraspinatus tear were almost alone in inducing radiological AHD (in seated or standing posture) of less than 6 mm. Moreover, such tears had to be longstanding. In practice, radiologic AHD equal to or greater than 6 mm is of no diagnostic relevance: the rotator cuff may be continuous, or showing full-thickness tear. Nor does it have any prognostic relevance: despite the absence of AHD reduction, subscapularis tear may still be non-amenable to suture repair. Complementary imaging, to assess the number of torn tendons and muscle FD is required. AHD < 6 mm indicates at least longstanding total full-thickness infraspinatus tear. AHD < 4 mm would seem to rule out any feasible infraspinatus suture; in that case, further imaging appears unnecessary. In case of 4 or 5 mm AHD, the infraspinatus tear may yet be suturable, and complementary imaging is contributive (Fig. 1).

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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